Intelligent Agents for the Semantic Adaptive e-Learning System

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ABSTRACT
The success of Web technology has built e-Learning a common success way of education and training. To provide online automatic adaptive learning content , this paper suggest a framework for building such learning management system based upon MAS(Multi Agent System) , Semantic web ontology and learners preference knowledge base for content resource organization , sequencing (learning path) and adaptation. This system has been built upon a famous learning management system called MOODLE and it facilitates and demonstrates the simulation in a real time teaching learning process. The result also show that the proposed e-Learning system has the highest possibility of score / rank gain in the selection of learning object retrieval technique

KEYWORDS
Intelligent tutor system , Multi agent, Ontology , e-Learning.

1. INTRODUCTION
Now a days learners are often confused with the large amount of learning contents , various content formats , different methods of accessing them and more standards to be followed while teaching or learning through web based education system . To identify information that suites their needs in terms of their prior knowledge level , preference , learning style , learning personalities , interest and so on so forth , the adaptive system that uses learners need and concepts models to provide a personalisation to create a unique learning experience (learning path) for each learners (1).

A number of personalised system have been developed on explicit information specified by a learner through demography, questionnaire and etc., have been applied for adapting the presentation and navigation(2).

There is no a common learning style that fits all types of learners due to two issues of challenge in adaptation.

1. Varying levels of knowledge of the individual learners
2. Users modifiability

The first one is solved by the LMS (learning management system) whereas the second is learner centric / focused which needs to be solved with the help of the advanced technologies like anthologies and intelligent systems(3).

By measuring the learners performance in recommending the learning content based on collaborative filtering , content based filtering and hybrid filtering , the recommendation system recommends top n learners that have similar knowledge level(4).

The semantic web mining technologies in the e-Learning system can provide solution to the provision of personalisation or adaptation through ontology creation and usage mining(5).

The offline module and online module which recognises the learners need and goals and predicts a recommendation list in terms of learning objects by filtering techniques (6).Ontology supported webpage crawler, webpage classifier , information extraction , information integration and recommendation ranking proved the outcome to achieve an excellent precision rate on webpage refinement(7)

The intelligent decision making agents with its autonomous , reactive and proactive behaviour have been used in the design and development of dynamic e-Learning process for personalisation through virtual learning environment(8).

The SCORM , IMS , LOM and AICC facilitates standards for indexing and searching of learning objects from various learning object repository through a practical ontology query expansion algorithm of semantic aware learning object retrieval (9).

The innovative , comprehensive semantic search model which extends the classic IR model address the challenges of massive and heterogeneous web environment and integrates the benefits of both keyword based and semantic based search techniques(10).

2. E-LEARNING STANDARDS
To associate the sharing and reusing of learning materials in different e-Learning system , several standard formats including SCORM , IMS , LOM and AICC etc recently have been proposed by several international organisation . These standards also facilitates the indexing and searching of learning objects across different set of learning object repository systems .

SCORM is developed by the ADL (Advanced Distributed Learning) initiative US Defence department for the creation of reusable learning content used as instructional objects with in a common technical framework for web based teaching learning system . All these standards , guidelines and specifications are interacted with one another.

IEEE LOM Uses pre-defined and common vocabulary to describe the teaching material contents which inturn contains nine categories of attributes like general, lifestyle, metadata , technical, education, rights , relations , annotations, and classifications. This process is similar to the system where we used to locate library books of our interests in the respective rack of book shelf. Learning object metadata guides the learners to locate the learning objects by using its title description, locations and other relevant attributes. Few of such metadata can be used in our customisation and adaptation with the help of semantic web ontology.

The learning objects are electronic document deliverable to the web client learners in the form of sounds , text , images and videos clipping etc.

SCROM also provides the runtime environment (RTE) where the information is transferred are exchanged across different LMS and the current SCO (Sharable content object). One of the drawback of SCORM is its inability in adaptation based on learner centric one . Because SCORM is mainly a instructor based sequencing rule based delivery of leaning content to the learners. The delivery decision is made by the information of current learner's interaction with LMS. They do not take in to account the external attributes such as learner's preferences and knowledge level database.

3. RESEARCH AIM IN THE PROPOSED ELEARNING SYSTEM

There are mainly two types of adaptation system exists in e-learning. One is content based and other one is link level adaptation. In content level adaptation normally uses the scoring metrics like word frequency document location and word distance to provide the ability to adapt the learning content to the learner. Whereas in link level adaptation the importance of the link is calculation from all the other important link that refers to it.

This research aim is to build a model for adapting learning objects in learning management system based on learners need, learners preferences and knowledge base of learners. User modelling phase of the research identifies and classifies the learner in the system to fitting the learning content for adaptation. Link level adaptation is mainly focusing the order in which the learning contents should be presented to the learners based on his learning style.

As discussed in introduction SCORM has limitations in adaptation due to instructor focused sequencing , the semantic web ontology is used for modelling course topics and learners interaction with the LMS.

The interaction and collaboration between different LMS is established through wrappering techniques so that the adaptive system dependency on the type of LMS used is avoided (11).

Since the proposed system is based on multi agent system , the agents characteristics like autonomy, pro-activity , reactivity and co-operability can increase the teaching learning process quality by filtering the learning contents . The agents collect s the information relevant to the learners , select the relevant contents from the LMS , organise the course topics and finally presents the learning material to the learners through individual agents. Agents also simulates the human side of learning.

There are five types of agents exists in the proposed systems

1. Learner modelling agents : this agent is responsible for current learner's model with respect to the current context environment through the concept of intelligent personalisation technique .
2. Topic Selector agent : as the learner chooses the course , this agent selects the course topics which are appropriate to the learner .
3. LO agent : Once the course topic is identified by the learner through selector agent , this agent decides which learning object package is to be delivered based on the learners learning style .
4. Presentation agent: The total information which are all collected through the above agent , this agent submits presentation logic to the LMS for the best selection of learning packages.
5. Ontology agent: This agent retrieves the ontology about the learning content from the ontology repository through ontology API.

4. SYSTEM ARCHITECTURE

This system architecture shown in Fig 1 extends the following prototypes which are already exists in the computational and information era.

1. Service oriented architecture(SOA)
2. Multi agent systems(MAS)
3. Semantic web ontology(SW)

The SOA concepts help the system so that different components offer a collection of services to other peers. To avoid the dependencies and promote the interoperability among the components, SOA service layers are used in the interconnection of LMS systems. Any LMS can be easily integrated with the proposed adaptive systems through web services irrespective of the platform in which it operates.

The next internal components of this architecture are following multi agent systems for agent container, agent management system and API interfaces. The expected benefits of agent technology are briefly discussed below

- Agents can improve performance over client server approach, especially in the situation that the registration data and agents code are small in size.
- Agents react to changeable situation to protect the learning resources.
- Agents can compare and select the suitable resources to the students during its travel.
- Agents can return the learning resources back to the students

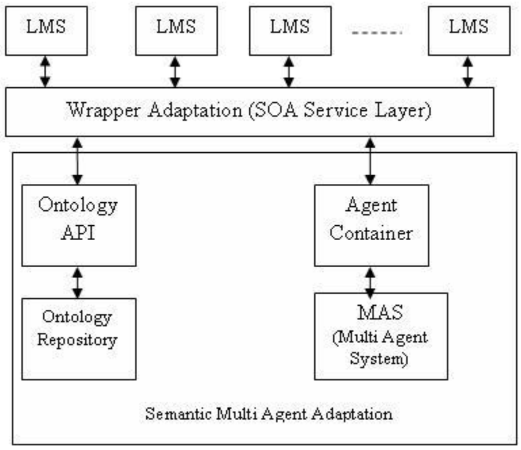

Fig 1 : System Architecture

The next last technology which we used in the system is semantic web ontology.

Recently the area of semantic web is coming to add a layer of intelligent in information retrieval technique. In this work we have investigated how the semantic web technologies and in particular ontology can be incorporated in the e-Learning domain, especially in adaptation system. Ontology offer a way to cope with heterogeneous representation of learning resources . An ontology can formulate a representation of learning domain by specifying all its concepts and possible relations in constructing knowledge based for further extraction of useful learning object in adaptive views of e-Learning system . In this case the ontology are used for describing the semantic and defining the learning context of the materials as well structuring the courses. From the semantic perspective four concepts exists in the systems like learner, learning object, learning object context and learning object content package.

Learning Style Model

The Learning Style proposed by the Felder –Silverman Learning Style Model(FSLM) have been used in this work due to the three reasons[12].

1. This model provides the Questionnaire to establish the dominant learning style of each learner
2. the result can be easily integrated to e-learning systems
3. this model is sufficiently validated in many adaptive environment

Once the Learning Object using this model is classified ,it is possible to deliver contents adapted to learners learning style. The Learning Style corresponds to the dimensions of the FLSM as listed below.

Learning Style	Questions and Answers
Visual / Verbal	I Prefer to get new information in • Pictures, Diagrams, graphs and Maps • Written Directions or verbal
Sensing/ Intuitive	I Prefer to Learn from • Concrete Material Like Facts/Data Examples • Abstract Materials like definition, principles and theories
Inductive/ Deductive	I Learn • At a Fairly regular pace, if go step by step • It fits and starts, I will totally confused then suddenly it all clicks
Sequential/ Global	When I am learning something new, it helps me • Be presented first with principles and then be provided with examples • First see its practical side then learn the principles

Design of Agents:

As discussed earlier five types of agents are introduced in this system and which are created by the JADE (Java agent development environment) at system start-up and will live infinitely. The occurrence of events is stored in the event lock file and agent will react with the system by interacting with the LMS accordingly.

The ontological memetic Distributed Agents platform provides an integrated approach towards achieving personalization in e-learning environments[15].

Design of Ontology

The system accepts active user session and also takes into consideration of the ontology of the domain which came from user transactions. Using OWL (Web ontology language) the system concepts like course topics learning sequence, learner model and learner interactions are represented. The ontology API OWL Reasoner is used for accessing the ontology repository for inferring logical consequences from the reasoner. [13]

The Following figure shows the Layout of domain ontology of a typical course "Object Oriented Programming"

The Course class contains several properties: courseName and courseDescription are the name and a brief description of the course, csHasObjective points to the objectives to reach (classObjective), whereas hasConcept (belongsTo is its inverse) and hasResource point to the set of concepts and resources, respectively, that compose a course.The concepts constitute the knowledge of the treated domain and they are collected in class Concept.This class contains data type property conceptName, toidentify the concept, and other object properties that allow to establish different relations among domain concepts: (a) consistOf serves to define a concept hierarchy, and therefore, to establish a relation among a concept and its sub-concepts (e.g. we are able to define chapters, sections, subsections and terms which are under sections), until reaching an atomic concept which - from the point the view of the teacher – does not need to be decomposed any more, (b) similarTo and oppositeOf make it possible to map a concept to other concepts that have the same or different semantic meaning, respectively, (c) nextConcept and peviousConcept indicate the concepts through which it is possible to advance/go back from a given concept – the browsing possibilities reflected with these two properties do not impose any constraint on the mapped concepts to be known or not, and (d) hasRequisite and isPrerequisiteFor (its inverse) allow to point to concepts that must be known before starting to study a concept, and the concepts for which it is a prerequisite, respectively. In this case, some conditions should be fulfilled to accede to the study of the concepts. On the other hand, with the study of a concept, a collection of objectives pointed by the object property ccHasObjective is achieved. The object property isDescribesBy (class Concept) points to digital resources that explain a concept or assess the knowledge stored about it. The capacity of obtaining a high grade of reusability for a learning object is largely a function of the granularity of the objects. We consider the learning objects that have a very low granularity as resources, that is to say, at the level of paragraph, image, table, diagram, and so on. Thus, in every moment an e-learning system is able to add/remove contents at this level and to produce tailormade learning materials according to the preferences of a student. Also, this facilitates showing didactical materials in those devices that have a screen of limiteddimensions (PDA) in form of a sequence of pages.

Learning objects that have a bigger granularity are built from smaller granularity ones. For instance, the course chapter's section will be created by mixing several little chunks (this is the way we have named the resources), the sections will form the chapters and the latter a course. Thus, by means of this process we are able to reuse learning objects at different levels.

A resource can be included in several courses (object property includedIn – hasResource is its inverse), and it can reference several concepts (objectproperty describes – isDescribedBy is its inverse).Moreover, class Resource includes an object property hasDescription to point to the description of class ResourceDescription, where more metadata that describe a resource are described. As you may observe,a resource (a) is created by one or several authors (property createdBy), (b) has a set of keywords that describe it (property hasKeyword), (c) helps to reaching a few objectives (property helpsToAchieve),(d) is located in a certain direction (property location),(e) is written in a given language (property language),(f) has a brief description (property description), (g)incorporates a type of interactivity - it can take valuesactive, exhibition and mixed - (property interactivityType), and, (h) possesses a grade of difficulty - very easy, easy, average, difficult, and very difficult - (property difficultyLevel). The type active applies for documents where the student interacts and/or performs operations (for example, simulations, exercises, test questionnaires), whereas exhibition is applied to documents whose objective is that the student gets the content (for example, text, images,sound). Lastly, in order to point to the learning styles that are better adjusted to a resource and that are more correctly visualized on a device, object properties hasLearningStyle and requiresDevice, respectively, are introduced.

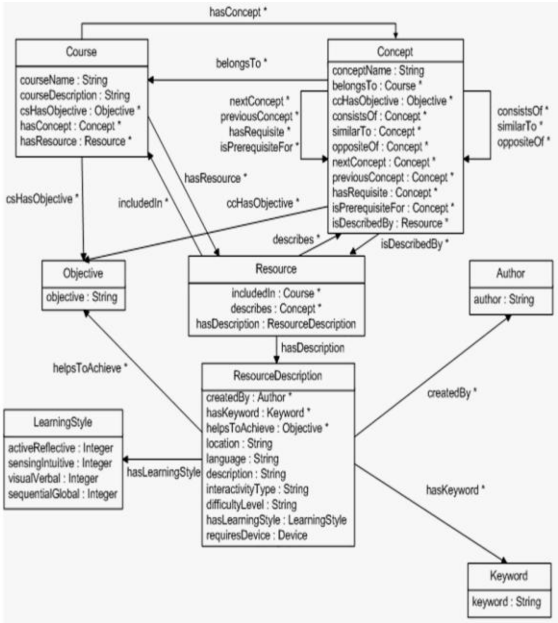

Fig 2 : Domain Ontology

The overhead in domain ontology creation by using text-mining techniques, concept graph extraction, and ontology learning, which should make LOCO-Analyst easy to deploy in different domains.[16]

Difficulty Level of the Concept Materials

Difficulty Level – Index	Meaning	Quantified Integer
D1	Very Easy	-2
D2	Easy	-1
D3	Moderate	0
D4	Hard	1
D5	Very Hard	2

Assume that D = { D1, D2, D3, D4, D5 } is a set of material difficulty level. Later this difficulty levels of learning material is updated automatically by the collaborative voting equation

$$Vj\ (voting) = \frac{\Sigma\ nij\ Di + Vj\ (initial)}{Nj+1}$$

Vj - Average Difficulty level of the j th material
Vj(initial) - difficulty level of the j th material assigned by the expert
nij - no. of leans whose response to the ith difficulty level of the jth material
Nj - Total no. of learners that rate the jth course material
$Nj = \Sigma i{=}1\ nij$

Estimation of Learners Activity

Assume that a learner responds to a set of a course concept material with pattern (u1, u2, …. Uj, … un), where Uj = 1 or 0 for the jth course material. In the response pattern if uj = 1 represents that the learner can completely understand the selected material. Otherwise if uj=0 represents that the learner can't completely understand the material.
In order to estimate the learners ability, the maximum likelihood estimation is applied as illustrated before.

$$L(u1,u2,u3,\ \ldots,\ un/ø) = \Pi j{=}1\ Pj(ø)\ Qj(ø)$$

$$\text{Where } Qj(ø) = \frac{e(ø - Vj\ (voting))}{1+ e(ø - Vj\ (voting))}$$

$$Qj(ø) = 1 - Pj(ø)$$

Pj(ø) denotes the probability that learners can completely understand the Jth course concept material at the level before ø.

Qj(ø) denotes the probability that learners cant understand the jth course material.

Material	Ability of Learner A
Material 1	Understand
Material 2	Understand
Material 3	Not understand
Material 4	Understand

In the above table, learner A can understand material 1, 2 and 4 but cant understand material 3. Thus the learner response pattern is (1:1,0,1) and the MLE is representing as

$$L(u1,u2,u3,u4)|\ ø) = \Pi\ Pj(ø).\ Qj(ø)$$

$$= P1(ø).P2(ø)\ Q3(ø)\ P4(ø)$$

Scenario
The following steps illustrate in more detail how the agents interact in our chosen exemplary e-learning use case:
1. A Learner starts his/her personal Learning agent (LA) to search for a suitable Learning Object under a particular course topic of a course, and logs in.
2. The LA loads the OWL Concept material ontology and the OWL instance data representing the Concept Materials Difficulty Levels as Concept Material knowledge base.
3. The Learner can enter some preferences regarding his/her interest (e.g., the subject of study, the teaching language, desired location). The LA extracts the specified parameters and queries further personal data (e.g., Difficulty level of the Concept Materials and Learners ability) from the knowledge base. Then the LA sends a request to the Learning Topic Selector Agent (TSA).
4. The TSA collects instance data about all Learning Concept material as well as about the Difficulty level of the subjects.
5. Then the TSA reasons on the knowledge base, aggregates the results and sends a ranked list of appropriate to the Content Presenter Agent.
6. The Content Presenter Agent retrieves the result from the LMS and presents it to the Learner

5. CONCLUSIONS

We described how Semantic Web and Agent Technology can be integrated to build an intelligent adaptive system for an e-learning environment. Our goal is to create and deploy semantic advisory agents capable of supporting learners in successfully organizing and performing their studies. The first issue of our architecture is to model the knowledge used in adaptive systems by means of the Semantic Web. Ontology languages like OWL can express the domain concepts, its structure and interrelations. In Semantic Web architecture, all information is spread over the Internet in the form of different OWL instance and schema files. As in reality, the knowledge of the agents is not static, but expanding during the counselling interview. Depending on the state of the

interview, agents dynamically collect their knowledge from different sources in the Semantic Web and integrate it in their personal knowledge bases of the inference engine. Additionally, each agent possesses private data, which has to be protected against unauthorized access. As in a real consultancy, an agent only reveals sensitive private data, if it is crucial for finding a solution.
In further work, we plan to extend our demonstrator, and to investigate how to employ further ontologies like ontology for educational models. This will enable us to add additional rules to enhance adaptive functionality based on the facts modelled in the knowledge base by utilizing additional relationships.

6. REFERENCES

[1] Damjanovic, V., Kravcik, M. & Devedzic, V. (2005). An approach to the realization of personalized adaptation by using eq agent system. In Paper presented at workshop on personalization on the semantic Web: Held in conjunction with the 10th international conference on user modeling (UM'05), 24–30 July, Edinburgh, UK.,

[2] Jung-Hung Shiu,Shiu-Li Huang, Adaptive elearning 2.0 ,Elsevier jouirnal of Expert Systems (2009)

[3] Magoulas, G., Papanikolaou, K., & Grigoriadou, M. (2003). Adaptive Web-based learning: Accommodating individual differences through systems adaptation. British Journal of Educational Technology, 34(4), 511–527.

[4] Khairil Imran Ghauth,Multi media University,Measuring learners performance in e-learning recommender systems,Australasian Journal of Educational Technology (2010) 764-774

[5] Penelope Markellou,Loanna Mousourli,University of Patras,Greece,Using Semantic Web Mining Technologies for personalized e-Learning Experiences (2009)

[6] Mohamad Koutheair,Mohamad Jemni and Olfa Nasraoui, Automatic Recommendations of e-Learning Personalization based on web usage mining techniques and information Retrieval,Education Technology and Society,12(4) (2009)

[7] Sheng-Yuan Yang,St.Johns University,Taiwan Developing an ontology-supported information integration and recommendation system for scholars ,Elsevier journal of Expert Systems with Applications(2010) 7065-7079

[8] Dongming Xu,Huaiqing Wang,Hong Kong,Intelligent Agent Supported Personalization for virtual learning environments,Elsevier Decision Support System 42(2006)

[9] Ming-Che Lee,Kun Hua Tsai,Tzone I,National Cheng Kung University ,Taiwan ,A Practical ontology query expansion algorithm for semantic –aware learning objects retrieval(2008) 1240-1257

[10] Miriam Fernandez,Ivan Cantador ,UK Semantically enhanced information Retrieval:Ontology-based approach ,Elsevier Journal of Web Sentics:Science,Services and Agents on the Word wide Web (2011)

[11] M. Yaghmaie, A. Bahreininejad A context-aware adaptive learning system using agents/ Expert Systems with Applications 38 (2011) 3280–3286

[12] José M. Gascueña, Antonio Fernández-Caballero & Pascual González Laboratory of User Interaction and Software Engineering (LoUISE) Domain Ontology for Personalized E-Learning in Educational Systems

[13] C. I. Peña, J. L. Marzo , and J. Ll. de la Rosa Intelligent Agents to Improve Adaptivity in A Web-Based Learning Environment

[14] Jinhua Sun. Yanqi Xie, China Xiamen University of Technology, XMUT A Recommender System Based On Web Data Mining for Personalized E-learning

[15] Giovanni Acampora,Matteo Gaeta, and Vincenzo Loia University of Salerno, ITALY ,Exploring the e-learning through ontological memetic agents, IEEE COMPUTATIONAL INTELLIGENCE MAGAZINE MAY 2010,66-77

[16] Jelena Jovanovic´ , Vladan Devedzˇic´ University of Belgrade Dragan Gasˇevic´ Athabasca University, Marek Hatala, Timmy Eap, and Griff Richards Simon Fraser University Christopher Brooks University of Saskatchewan Using Semantic Web Technologies to Analyze Learning Content IEEE INTERNET COMPUTING 45-53